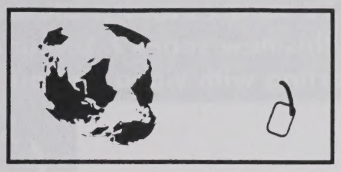
SPACE
Pacific



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Within the coming 12 months, virtually every buyer of television equipment will be faced with a decision: "*Digital or analogue?*" Very low cost MPEG-2 encoders will begin to appear in Camcorders and home PC products by the end of 1998, making it possible for individuals to create (and transmit) MPEG-2 digital rather than only be able to receive digital signals. In no product line is the movement to digital more established than in home (and commercial) satellite receivers. The plain and simple truth is, "*Unless you are conversant in digital technology, you will find yourself hopelessly behind in the satellite and consumer electronics world.*"

In this issue of **Teck Notes**, a multi-part (4 segment) series first published in the English trade journal "Television (Magazine)" which presents the world of digital as it relates to video and then to satellite TV in a format which anyone familiar with analogue technology should have no major difficulty grasping.

Also in this issue, a straight forward explanation of the new and for most of the Pacific still mysterious DiSEqc control system created under contract by Philips for use by the European Eutelsat multi-satellite system. We may not be on the verge of having multiple satellites stacked up at the same geo-stationary location in the Pacific and Asia (as they already do in Europe), but we are already having to deal with receiver products that include the DiSEqc system included. This report will help you better understand what DiSEqc is and does, and perhaps give you some ideas on how you could use it for purposes never conceived by Philips.

Installer/Dealer Member Data Base

Commercial firms, in particular in the data (Internet) field, are now routinely contacting **SPACE** to ask for assistance in locating "qualified, capable installers" to do C and Ku-band installations under contract. We ask that Installer/Dealer as well as Retransmission and IMP Members complete the survey form attached to this issue of **Teck Notes**. This will place your firm into our "Installation Capable" data base which we believe will lead to contract work in the months and years ahead. We will resurvey members in a year's time to obtain updated information.

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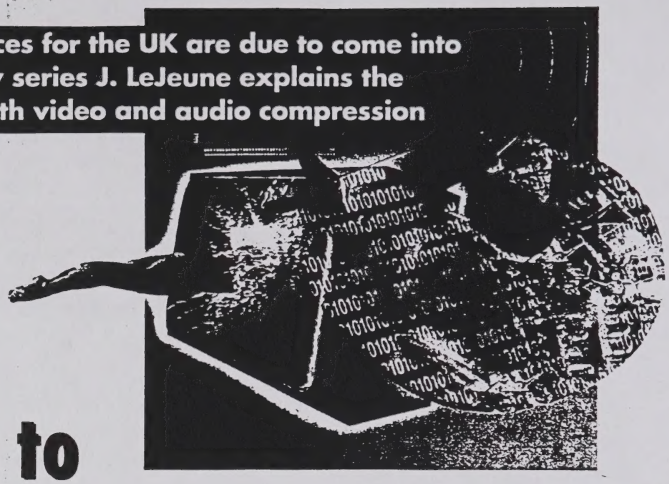
SPACE Membership Teck Notes is compiled by SPACE Pacific to assist members in their own understanding of the ever changing technology in the field of satellite communications and reception. Some material appearing here has been previously published outside of the Pacific + Asian regions and is made available to members for purposes of building a "reference library" of this fast changing technology. SPACE offers members the opportunity to advance their own formal training through the Mark Long SPACE Pacific "study at home" technical courses each of which makes possible a certificate upon successful completion of a course of study.

Terrestrial and satellite TV services for the UK are due to come into operation next year. In this new series J. LeJeune explains the techniques involved, starting with video and audio compression



Introduction to Digital TV

The United Kingdom is to have digital TV services before long. Although there has been some slippage in the programme for the start of transmissions, if all goes according to plan digital satellite TV will be with us next March and digital terrestrial TV next summer. The former will make dozens of channels available to viewers, the latter some thirty channels.

Digital TV uses a lot of processing to deliver pictures and sound. Some of this processing is complex. The aim of this four-part series of articles is to explain briefly and clearly what is done, so that readers will be familiar with the basics of the technology when they find themselves confronted with the snags which will inevitably arise in practice. We will be explaining the differences between satellite, cable and terrestrial transmission methods as we go along.

Why Signal Compression is Needed

The analogue luminance and chrominance signals produced by the cameras first have to be sampled at regular intervals, with each sample then converted into digital form. Luminance signal sampling is carried out at a rate of 13·5MHz. The two analogue colour-difference signals (B – Y and R – Y) are sampled at a rate of 6·75MHz. Thus 27 million samples are generated every second.

A TV picture is normally described as consisting of 625 horizontal lines (in Europe anyway), with a complete frame of 625 lines scanned out 25 times a second. In digital terminology the television line is also divided into pixels, the new term for picture elements. There are 576 active lines in a 625-line picture (the others are taken up by the field flyback period). With an aspect ratio (picture width to height) of 5:4 and equal horizontal and vertical resolution, there will be 576 x 5/4 pixels per line, i.e. 720.

Each pixel has three values associated with it, a brightness (luminance) measure and two colour-difference measures, Cb which relates to B – Y and Cr which relates to R – Y. Because colour has a lower resolution (picture detail is indicated by differences in brightness level), one pixel of each colour measure accompanies a block of four luminance pixels.

With a grey scale capable of distinguishing 256 different levels, eight digital bits are required per sample. At a sampling rate of 27 million per second, this works out at a data rate of 27 x 8 = 216Mbits/sec. Using the simplest modulation system available for a digital system, pulse-code modulation, the transmitted signal would require a bandwidth of over 100MHz. So there clearly has to be considerable compression of the data before a digital system can rival an analogue one in terms of spectrum economy.

Basic System Requirements

At the time when our current analogue TV standard was set in stone there was little to be had by way of large-scale, fast-processing integrated circuits. The task of establishing a digital service in the days of valves would certainly have been impossible! Nevertheless the pioneers of the day conjured up magic with the components that were available at the time.

For digital TV to be worthwhile, it should be able to exceed the performance of an analogue system by a very substantial margin. It relies on three factors, which together provide very powerful magic indeed! They are:

(1) Compression of the picture and sound data.

(2) Large semiconductor memory capacity.

(3) A modulation technique that's matched to the transmission requirements.

The prime difference between analogue and digital TV is that with analogue TV the complete picture is transmitted and rewritten on the CRT screen once every 40

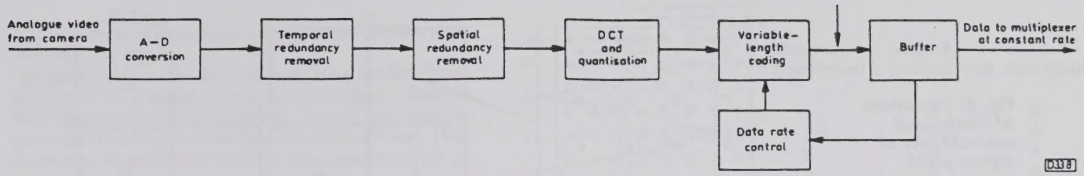


Fig. 1: Basic block diagram of MPEG-2 video processing, from the camera's analogue output to the transmission multiplexer.

milliseconds (25 pictures per second), whereas with digital TV the picture data is loaded into memory and only information on picture changes from frame to frame is transmitted. At the receiving end, this data is used to modify the memory-stored picture. The updated picture is then read out of the memory and presented on the screen as a normal picture at the standard 25 frames per second. With a still caption, at one extreme, very little data needs to be transmitted. With a fast-action, laser-blasting intergalactic battle at the other extreme the transmitted data rate will be the maximum the system can convey.

The data compression system used for digital TV is called MPEG-2. It's a 'sort-of' standard which is very flexible, with several levels of compression and alternative modes of picture recreation. The MPEG-2 standard at present adopted worldwide is the variant known as "main profile, main level". Fig. 1 shows in block diagram form the signal processing chain from the camera to the feed to the transmission multiplexer.

The terminology used for digital TV can be a stumbling block for those used to analogue systems. Unfortunately some of the long words seem to be used less because they are the best way of describing a process than because they make it sound complex. MPEG-2 is not simple, but it need not be too frightening!

Redundancy

As Fig. 1 shows, signal analogue-to-digital (A-D) conversion is followed by redundancy removal. This is where the data processing starts. There are two stages, temporal and spatial redundancy removal.

It is often said that for much of the time one TV frame is very much like its temporal neighbours. Adjacent lines of the picture are also very similar for much of the time (advantage is taken of this fact in VCR drop-out compensation). After A-D conversion, the video data in successive frames is examined to check on the similarities and differences.

The temporal redundancy process, which is also known as interframe compression, compares successive frames to see which parts of the picture have changed. Only the changes that have occurred from one frame to the next are passed on. See Fig. 2. With a lot of programme material the temporal redundancy can be as much as 98 per cent.

After removing the repetitive video data in successive frames, the contents of the frame itself are examined. This is the spatial redundancy process. Where for example a line has a long section with the same brightness and colour, a short code is used instead of data repetition pixel by pixel. Fig. 3 gives an idea of this process. Suppose, for example, that the top line of the picture consists entirely of clear blue sky. The data for the line could be transmitted pixel by pixel, but this would mean repeating the same data 720 times just to describe the line. Instead, the repetitive data is coded in the following way:

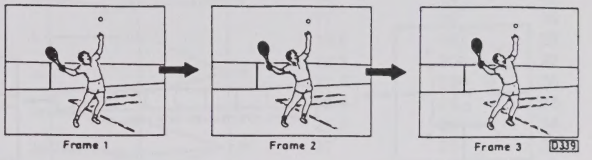


Fig. 2: Temporal redundancy. In frames 1-3 only the position of the racket changes. Given frame 1, this is the only information required to construct frames 2 and 3.

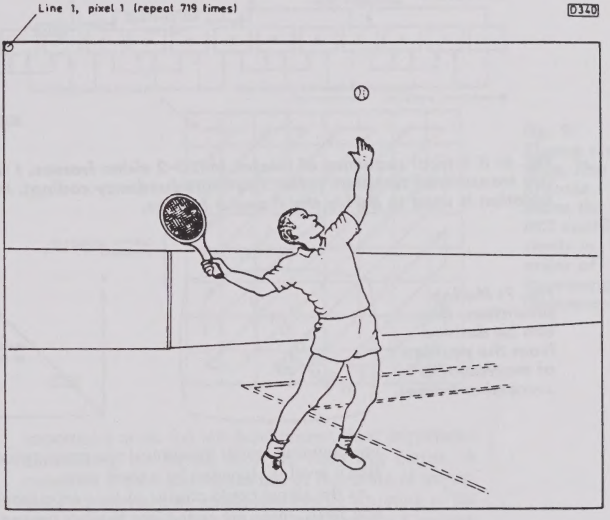


Fig. 3: Spatial redundancy. There is no change along the top line, which is coded as line 1, pixel 1, Y = 0·85, Cr = 0, Cb = 0·45, repeat 719 times. Most of the rest of the frame can be coded similarly.

(1) Position co-ordinates, i.e. line one pixel one.

(2) Luminance/chroma values, e.g. Y = 0·85, Cr = 0, Cb = 0·45.

(3) Repetition instruction – repeat 719 times.

The spatial redundancy process is also known as intra-frame compression. It provides a further contribution to lowering the data rate.

A further stage looks at all the other data sent with the picture. Sync signals, as used with analogue TV transmissions, are not sent. Their place is taken by pixel and

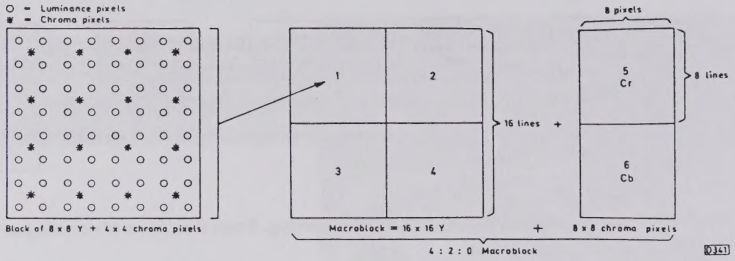


Fig. 4: Formation of blocks and macroblocks of digital pixel data.

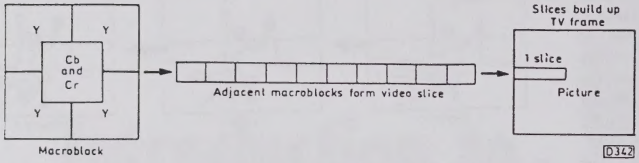


Fig. 5: Video data assembly into slices to form a picture.

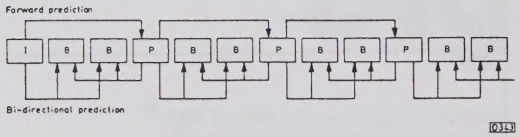


Fig. 6: A typical sequence of twelve MPEG-2 video frames. I frames are transmitted complete (after spatial redundancy coding). Interpolation is used to derive the P and B frames.

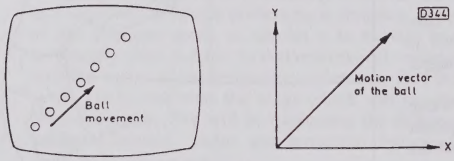


Fig. 7: Motion prediction. This can be derived from the position of macroblocks in successive frames.

line counting, under the control of a precise clock signal. Black level is signalled by a short code.

As the signal could consist of long repetitions of ones and zeros, these are coded into batches instead of being repeated bit by bit. Thus instead of say

11111100000000000111111

being sent, a statistical redundancy process batches the digits as "1,6:0,10:1,6". This is called "run-length coding".

Up to this point nothing has been irreversibly lost from the TV picture. Subsequent processing loses some of the data, relying on the eye being tricked into seeing what's not there. Similar techniques in the audio processing sections trick the ear in much the same way.

Finer Points

From this point on things get a bit more complicated, with discrete cosine transform (DCT, Fig. 1) and quantisation. Before the mathematical manipulations raise their ugly heads however, let's examine some of the finer points involved in temporal and spacial redundancy.

Getting rid of repeats is not the whole story of digital compression. There are more tricks to MPEG-2. Amongst them are motion prediction, quantisation and zigzag scanning.

Before any of these can be implemented, the data that represents the picture is split up into blocks, see Fig. 4. This shows the individual digital pixels organised first as a block of eight by eight luminance pixels with an accompanying four by four red and blue (Cr and Cb) chroma pixels. The basic blocks are further grouped to produce blocks of 16 x 16 luminance pixels and two 4 x 4 blocks of chroma pixels. These are called macroblocks. This grouping of luminance and chroma pixels is referred to as the 4-2-0 format. Other formats – the 4-2-2 and 4-4-4 – give higher quality with a corresponding data rate trade-off. 4-2-2 has four luminance, two Cr and two Cb blocks in each macroblock, while the 4-4-4 format has four luminance, four Cr and four Cb blocks.

The adjacent macroblocks that comprise each frame of non-interlaced digital video are then grouped into strings called 'slices'. The order of assembly is exactly that in which the picture was originally scanned, i.e. left-to-right and top-to-bottom. Slices are essentially data sequences which are arranged in this way to aid with error detection. When erroneous data is detected in a slice, the slice is ignored. Processing continues with the next slice in the series.

The video slices are assembled in sequence to form a picture, see Fig. 5. Note that in this context the term video refers to the data, not the familiar old analogue video waveform!

Intraframe Coding Sequences

The pictures (frames) are assembled in sequences of twelve, the first frame in each sequence being known as the reference frame, see Fig. 6. This first frame gives us a complete picture. It has been coded by the spatial redundancy process, but can be considered as independent of the other frames in the sequence. Such a frame is also called an I frame. This doesn't stand for independent but for Intraframe-coded picture. Naturally this frame is less compressed than the others. It serves as a starting point for the decoder when the receiver is either switched on for the first time for a session of viewing, or is switched from one channel to another. I frames normally occur at every twelfth position in a sequence.

There are two other kinds of frames, P and B. The P frames are Predicted frames, which require more than one frame for the prediction process. A predicted frame uses the nearest I or P frame as the prediction basis. It can serve therefore as a reference frame for other P or B frames later in the sequence of twelve. The disadvantage is that an error in a P frame can be repeated in subsequent P and B frames until the next I frame is received. Such an error would last for just under half a second.

The amount of compression with a P frame is more than that with an I frame.

B frames are constructed by interpolating the data from adjacent P or I frames, using past and future frames. They cannot be used as reference frames, and require more than two frames of storage (for interpolation). This represents an additional memory requirement, which is an extra cost in manufacturing a receiver.

Motion Prediction

Decisions about temporal redundancy are made by comparing corresponding pixels in adjacent frames. The macroblocks are used to predict the motion of something that moves. This is a relatively simple matter: as the picture is divided into rows (lines) and columns (one per pixel), precise positional information can be derived. Since timing in TV picture transmission is also very precise, the speed as well as the direction of moving blocks of pixels can be measured and further movement predicted. Only relatively small amounts of data need to be sent to describe this. See Fig. 7.

Motion prediction is valuable for correcting errors that occur between I and B frames, as an error signal which can be given a short code can be derived. Prediction is based on luminance information only, but is used for chroma as well.

Discrete Cosine Transformation

As part of the intraframe (spatial) coding operation, a complicated mathematical process known as a Discrete Cosine Transform is performed on each of the pixels in a data block. Basically the DCT process converts values from the time to the frequency domain, and takes advantage of the correlation between pixel values in a block. The resulting transformed block of data consists of the coefficients of the frequency components, with each component relating to the amplitude of a pattern within the block.

When there is high spatial redundancy, i.e. many adjacent areas of the picture have the same brightness and hue, the frequency component will be zero and the coefficient will be DC. If the picture contains much fine detail, the frequency component will be high and the coefficient will have a high value.

Conversion of a 16 x 16 block of pixels by the DCT process produces a matrix of numbers, the one at the top left corner being the only absolute number. The others are difference values, which can have a positive or negative sign. The resultant matrix represents rising horizontal frequency from left to right and rising vertical frequency from top to bottom.

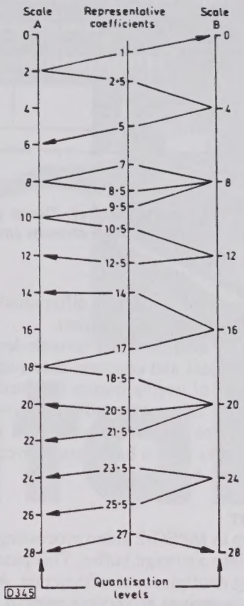
Quantisation

The values of the coefficients in each block are next quantised: each number is changed by rounding up or down. Fig. 8 best explains quantisation.

This process further reduces the amount of data that has to be transmitted, by reducing the range of values. With MPEG-2 processing the values are weighted, providing smaller steps for LF video information and correspondingly greater 'definition', while using coarser steps for HF information. As the human eye's perception of luminance graduation in finely detailed parts of a picture is limited, the quantisation steps (or scaling factor) can be larger and the definition more coarse. The overall scaling factor is also modified by the status of the output data stream buffer. More on this later.

Zigzag Scanning

The figures in the quantised matrix have maximum importance at the top left-hand corner, their importance diminishing the farther they are from this corner. A coded bit stream that makes use of this scale of importance is generated by employing zigzag scanning of the cells in each matrix (the original block of 8 x 8 pixels). This is illustrated in Fig. 9.



Original Coefficient	Scale A quantisation	Scale B quantisation
1	2	0
2·5	2	4
5	6	4
7	8	8
8·5	8	8
9·5	10	8
10·5	10	12
12·5	12	12
14	14	16
17	18	16
18·5	18	20
20·5	20	20
21·5	22	20
23·5	24	24
25·5	26	24
27	28	28

Fig. 8: The quantisation process, in steps of 2 (scale A) and 4 (scale B). Coefficient figures that are exactly half way between quantisation levels are rounded up to the next highest figure.

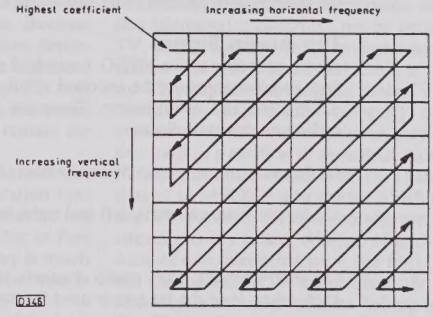


Fig. 9: Zigzag scanning. This process scans the DCT coefficients in order of increasing frequency.

Further Data Reduction

The bit stream can be further reduced by using run-length coding and variable-length coding. The latter is best exemplified by the Morse Code, in which the most common characters have the shortest codes – E is represented by a dot and T by a single dash, while Q and Y have the longest codes. Many blocks contain only zeros towards their ends: a simple 'end-of-block' code is transmitted when all the remaining digits in a block are zeros.

The top left cell in the matrix is not run-length coded. But, as comparisons are made from frame to frame of video, data saving can still be obtained. The top left cell, termed the DC cell, changes little from one frame to another. Thus the difference between the current DC cell and the corresponding cell in the previous frame can

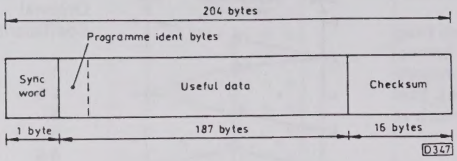


Fig. 10: Basic MPEG-2 data packet. These packets are the components of the transport stream (multiplex).

be transmitted. This is called differential coding, and aids the quest for bit-rate reduction.

The blocks are quantised and variable-length coding is applied to frequent and common data runs. Remember that at intervals of twelve frames the encoder transmits a full reference frame to enable those who have just joined the service to start decoding and to enable any cumulative errors which have arisen over the previous eleven frames to be eliminated.

The Buffer

The final step in MPEG-2 video processing is to feed the data stream into a storage buffer. This passes the data to the following multiplexer at a fixed rate. As the buffer's incoming data arrives at varying rates, it can on occasions overflow. To prevent this, feedback is applied to the quantisation process (data-rate control, see Fig. 1).

The Audio Signal

Audio encoding to the MPEG-1 standard enables one or two audio channels to be encoded at bit rates between 32kbits/sec and 448kbits/sec. There are four different coding modes, as follows:

(1) Mono. Simple single-channel audio.

(2) Stereo. Two channels, left and right, but with shared data.

(3) Dual-channel. Two mono channels independent of each other. Half the bit rate is used for each channel.

(4) A pseudo-stereo system, in which the stereo signal is filtered to produce separate LF and HF bands before coding. The HF band is shared by the two channels. This method reduces the bit rate. The receiver reconstructs the pseudo stereo signal.

Signals can be sampled using one of three bit-rate reduction schemes available with MPEG-1. These are called levels 1, 2 and 3. They operate at sampling rates of 32, 44·1 and 48kHz respectively. Decoders for the higher levels will also work at the lower ones.

The coding system is based on the psycho-acoustic characteristics of human hearing. This sets the lowest audibility level for a series of frequency bands. Sounds that fall below these levels are not transmitted. Further data-compression techniques known as adaptive differential PCM and backward adaptive quantisation make additonal useful contributions to bit-rate reduction without damaging the quality of the sound.

With MPEG-2 the two-channel audio capability is broadened to provide up to five channels per video broadcast. It remains downwards-compatible with MPEG-1. Audio quality is lower – it's the usual trade-off between bandwidth and data rate. Bit rates between 64 and 256kbits/sec are usual.

The audio data is multiplexed into the video data stream, forming part of the whole data stream of the multiplex.

Packets of Data – the Multiplex

We have now arrived at the point where the three components of a channel come together for application to the multiplexer, which combines the data for other channels to form a transmission multiplex of say four channels.

The data that arrives at the multiplexer consists of packets of video, audio and programme data. The latter includes identification codes for the services, time stamps for the packets to ensure simultaneous presentation at the receiver, and service information – an electronic programme guide.

MPEG has a layer system that organises these packets of data into a complex stream – the multiplex. It organises and controls the relationships between the data packets for each individual channel, to ensure that the correct data is sent to a receiver's decoder and that the sound and vision are synchronised.

The programme data enables the viewer to select the channel of his choice. It describes the make-up of the 'transport stream', and identifies and maps the positions of individual data packets within it. The transport stream is the result of multiplexing several channels. Obviously information has to be provided so that the receiver can select the channel required without getting the channels mixed up.

The Programme Specific Information (PSI) includes four basic 'tables' as follows:

(1) The programme allocation table. This maps the data carried by the transport system and correlates programme numbers with programme table identification numbers.

(2) The programme map table. This maps the data for a particular programme in the multiplex.

(3) The network information table. This carries information on all the network parameters, such as transponder numbers and frequencies.

(4) The conditional access table. This matches encryption data for a particular channel with viewing card data using the 'entitlement management' messages in the data stream. Service encryption is not mandatory, and any type of encryption can be employed.

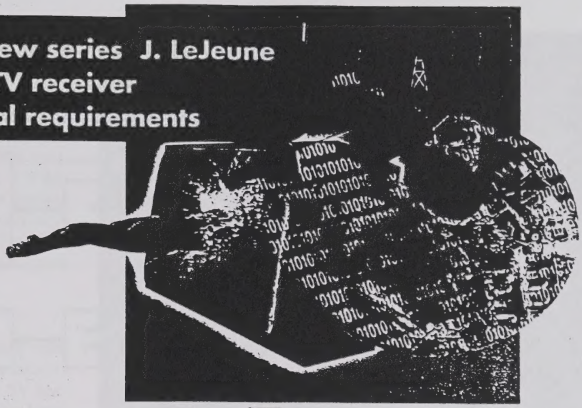
The MPEG Data Packet

The basic structure of an MPEG-2 data packet is shown in Fig. 10. It starts with a one-byte sync word. This is followed by 187 bytes of 'useful data', then 16 bytes of checksum. There are identification bytes at the beginning of every useful data section. These are used by the PSI to select packets that belong to a particular channel. Because time stamps are included, there is correct synchronisation of the picture and sound and any relevant data and on-screen messages.

Multiplexing

The packets of data are fed to the multiplexer whose output is a data stream, probably at 20-25Mbits/sec, for application to the transmitter. Further data processing is carried out depending on the transmission medium – satellite, terrestrial off-air or cable.

In this second instalment in his new series J. LeJeune takes a look at a typical digital TV receiver arrangement and considers aerial requirements



Introduction to Digital TV

Having examined the MPEG-2 video and audio data compression system which is to be used for digital TV services in the UK, we are in a position to look at a typical receiver arrangement. Because of the rapid development of new and ever more densely packed ICs, it is difficult to be too specific at present about final receiver layout. But whatever new ICs may be introduced for the purpose, the underlying principles of signal demodulation and processing will remain the same.

Since the transmission medium – terrestrial off-air, satellite or cable – dictates the signal modulation system used, this will determine the arrangement of the receiver's front end. We will be looking at this in Part 3 next month. The rest of the receiver circuitry is much the same whatever the signal source. The front end is generally referred to as the 'channel decoder'.

For terrestrial digital TV reception the channel decoder will tune across the the UHF bands and contain demodulation circuitry for coded orthogonal frequency-division multiplex (COFDM) signals. A cable channel decoder will cover the VHF and UHF bands and will demodulate 64-QAM signals. 64-QAM (quadrature amplitude modulation) is a variant of the QPSK (quadrature phase-shift keying) modulation system used for satellite digital TV transmissions. In fact all three modulation techniques are related, since they are all based on the use phase modulation.

Satellite TV Decoder

Fig. 1 shows a typical digital satellite receiver in block diagram form. The channel decoder contains the tuner, which is under phase-lock loop control from the microcontroller. It delivers separated I and Q (in-phase and quadrature) outputs which are converted into 6-bit digital form. The signals are then demodulated and presented to the forward error correction (FEC) chip. Forward error correction for satellite signals involves Reed-Solomon decoding and convolutional decoding using the Viterbi algorithm (sorry about that!).

To summarise this, after selection by the tuner the signal is demodulated and error correction is undertaken. With terrestrial and satellite systems there is in addition convolutional coding, which is required to prevent loss of data because of the transmission medium. Some of this additional coding may not be necessary with cable TV, which operates in an environment with better protection – its use is at the discretion of the cable company. This implies that a digital cable TV receiver may be specific to a particular company or network. The modem used in a cable receiver may also differ from that used in a satellite or terrestrial receiver.

The signal at the output from the channel decoder consists of an MPEG-2 data stream which may contain several TV services multiplexed together. This 'transport stream', as it's called, consists of packets of data, each with its own identification – see Figs. 2 and 3. The ID bits tell the next IC in the receiver, the transport stream demultiplexer, which packets belong to which service. The TS demultiplexer separates the packets and assembles them in the correct time sequence. It looks for the packets relating to the requested service, removes them from the transport stream and, after assembling them in the correct time sequence, passes them to the MPEG decoder chip for processing. The TS demultiplexer chip operates at a clock frequency of 25MHz.

If the demultiplexer detects a scrambled service it passes the data to the conditional access module, which contains descrambling circuitry appropriate for the system in use. A smart card is required for access to scrambled programmes: it holds information about which services have been paid for by the user.

The conditional access module is in a sealed can the size of a credit card but about 5mm thick. It has a PCMCIA connector at one end. Incidentally an unscrambled service such as CNN does not require the presence of the conditional access module, so a receiver can be tested without conditional access using such a service. Some cable TV receivers may have the conditional access module integrated on to the main receiver PCB.

Rebuilding the Pictures and Sound

Video data is sent from the TS demultiplexer to the MPEG video decoder via an 8-bit data bus. There is also

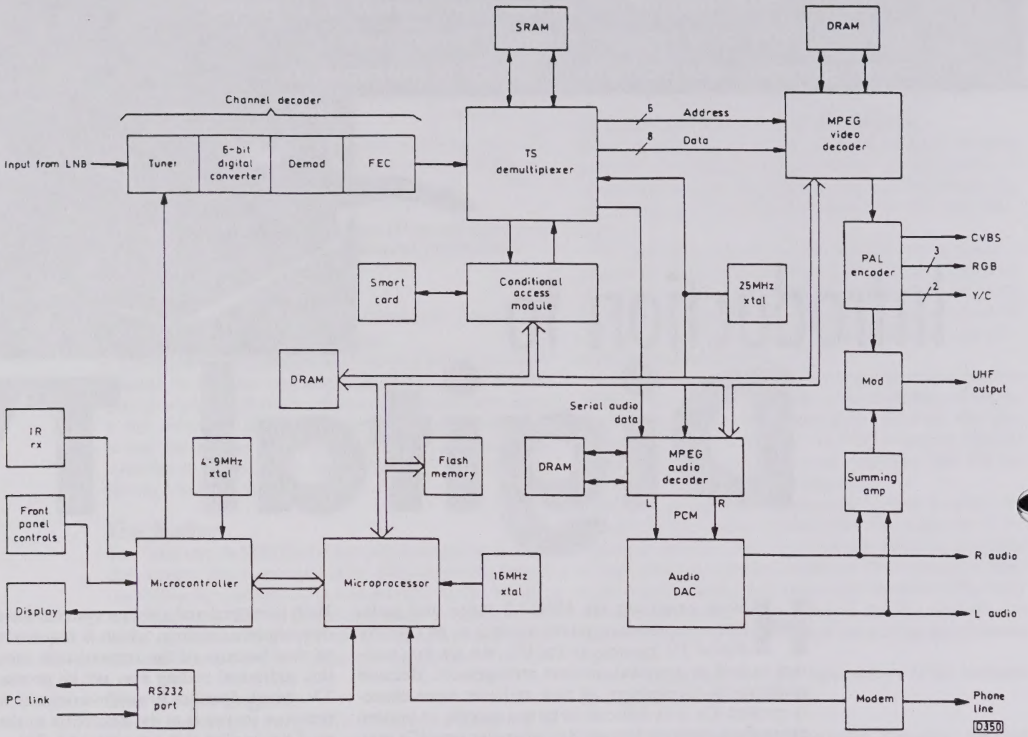


Fig. 1: Simplified block diagram of a typical digital satellite TV receiver.

a 6-bit address bus. Processing is controlled by the microprocessor, which uses the flash memory to store software programmes. These can be upgraded by transmitted data, giving the receiver a degree of future proofing. The flash memory is not unlike an EEPROM in that it is non-volatile, i.e. it retains stored data when not powered. But it cannot be overridden. Instead, data is stored first in a DRAM and then transferred to the flash memory block-by-block, using an erase/write/verify process. Thus off-air upgrading can take as long as ten minutes to complete.

Most receivers will have external access to the microprocessor via an RS232 port. The uses of this will include receiver fault diagnosis and flash memory upgrading by connection to a suitably-programmed PC. It's likely that fault diagnosis using a dedicated PC program will become common.

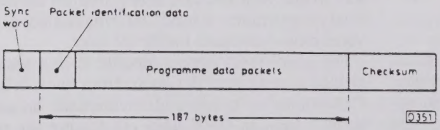


Fig. 2: An MPEG-2 data packet. The packet identification data enables the transport stream demultiplexer in the receiver to sort out the data packets.

The MPEG video decoder rebuilds the TV picture from the I (reference) frames and the P and B frames (see last month) that are transmitted. Most receiver video memories are just large enough to be able to handle I, P and B frames. In some receivers the B frames are not used, the frames being built up from I and P ones instead. This local B frame generation requires a greater amount of DRAM however.

Audio data is sent from the TS demultiplexer chip to the MPEG audio decoder chip in serial form. Audio processing is also under the control of the microprocessor. Another DRAM is associated with the audio processor chip to delay the audio output by up to a second. This is controlled by the packet time stamps to assure correct sound and picture synchronisation – the video data processing can take up to a second, particularly when it is scrambled. The outputs from the MPEG audio decoder consist of L and R pulse-code modulation (PCM). This is converted back to analogue form then passed to the UHF modulator and rear panel sockets. Stereo is combined to form a mono input to the modulator by means of a simple summing amplifier.

Control

The microcontroller chip performs all the usual housekeeping functions required in a receiver. It controls the tuning, sets the LNB polarisation, instructs the modem, produces the 22kHz tone and drives the LED display. It

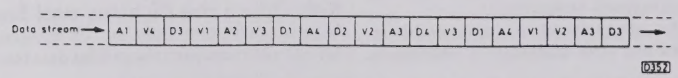


Fig. 3: Representation of the data transport stream, showing multiplexed video (V), audio (A) and data (D) packets.

communicates with the microprocessor chip when a menu is required and when data transfer is occurring, either over air or via the RS232 port.

At power up the microcontroller chip automatically selects the 'Home Channel', which carries the electronic programme guide in its data stream. The chip also controls a video output chip for selection of PAL CVBS, PAL S-VHS or RGB outputs. It provides standby control and monitors the front panel switches. Current receivers use a 76-pin surface-mounted microcontroller chip.

Fig. 4 shows a typical microcontroller/microprocessor control system.

Power Supply

The power supply will be of the switch-mode type because of its high efficiency and low cost. The receiver's basic logic supply will be 3·3V, with some 5V sections around the microcontroller and UHF modulator. There will also be 12V, 14V and 20V lines.

Increasing use is being made of integrated chopper/control chips such as the TOP range from Texas Instruments. Expect to find these and systems like them in many future power supply circuits. The devices are rugged and not easily destroyed by a fault condition.

Other Features

Other features of such receivers will be parental control and a PIN code to prevent unauthorised tampering and provide identification in case of theft.

When the receiver is switched on from cold it will go through a routine of checking and then tuning itself to the default frequency – usually that of the Home Channel. Once all is well a picture is available and the user knows that a service can be selected or the programme menu seen. As with analogue receivers, the manufacturer will have pre-programmed the receiver for the services available in the country of sale. Most receivers allow the user to change this into an order of preference.

Two kinds of digital satellite TV receiver are likely to be made available: basic ones, possibly subsidised, for services from a particular broadcaster; and more expensive types able to receive digital signals from anywhere in the section of the Clarke belt accessible in a given area. These will probably not have a conditional access system – to decode scrambled signals it may be necessary to purchase a decoder module and smart card.

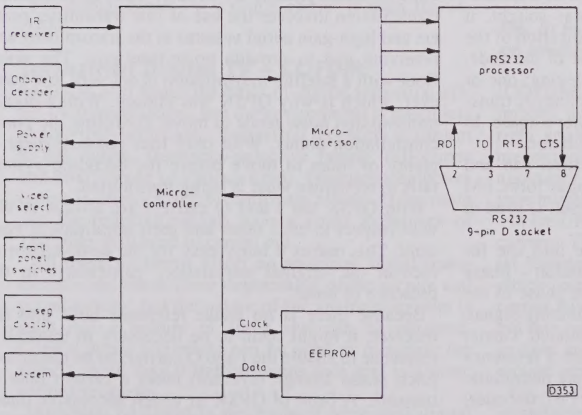
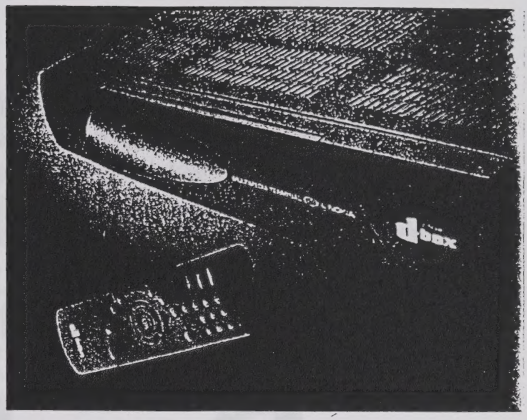


Fig. 4: A typical digital satellite receiver control system. The RS232 connector pins shown are receive data (RD) 2, transmit data (TD) 3, request to send data (RTS) 7 and clear to send data (CTS) 8.



Nokia's famed d-box digital satellite TV receiver.

Aerials

While dish installation will become easier as riggers gain practice, it will not be as easy as with an analogue system. The practice of alignment "on picture" may not be as simple because of the go/no go nature of digital reception. A good-quality signal-measuring instrument will provide the quickest and most satisfactory means of securing good and consistently high-quality reception. In most respects this will resemble a portable spectrum analyser.

Small dishes will be OK for digital TV. Terrestrial receivers operating at UHF can use the familiar roof-top Yagi aerial but, because of the type of modulation used, a set-top aerial will provide excellent pictures in most service areas.

Satellite digital TV reception requires the use of high-quality cabling and connectors to prevent reflections where there are items that have a poor match at 75Ω. Reflections can cause inter-symbol interference, and may prevent a picture being resolved at all. Because of the ruggedness of the transmission system, this may not be such a problem with a terrestrial installation – but this should not be an excuse for poor installation work.

Cable

Cable subscribers will have intersting additional services. Fully interactive operation with some of them is a distinct possibility, because of the provision of a fast data link going upstream to the network's head-end. The speed of the return path is much greater than that available with the public telephone network, because of the greater bandwidth available with coaxial and fibre-optic networks.

Modem

All future digital receivers will probably include a modem which, with satellite and terrestrial receivers, will be connected to the telephone system. Modems used in cable set-top boxes will be much faster devices.

Corrections

The wording above the arrow on the right-hand side at the top of Fig. 1 last month was omitted because of some sort of printing computer mix up. It should have said "variable bit-rate data" – the buffer is used to read out data at a constant rate.

The first word in line six under the heading "The MPEG Data Packet" last month should have been TSD not PSI.

This time J. LeJeune describes the modulation techniques used for digital TV transmission and the reasons for employing different systems for satellite, terrestrial off-air and cable broadcasting

Introduction to Digital TV

It is often said that there is nothing new under the sun, which in many cases is true. Take the transmission of digital signals for example. The first Marconi wireless transmissions were digital in nature, using on/off signalling and the Morse Code. The transmitter was manually keyed by using the Morse key, the carrier being on to signal a dot or dash.

Forms of Modulation

This is a kind of amplitude modulation, as the carrier is made to vary between zero and 100 per cent by the code characters. The actual term given to this mode of transmission is CW (continuous wave) – which it clearly isn't because the carrier is transmitted only when the Morse dots and dashes are being sent! With the key in its up position, there is no transmission. The method is slow and requires two operators, one at each end, to encode and decode the messages ('traffic').

Message transmission was speeded up with the advent of the teleprinter, using the 7-bit Gray Code. It could also be automated. A better method of transmitting the teleprinter signals ('RTTY') was sought: it was felt that there should be a positive indication of the off (space) as well as the on (mark) state of the code. This led to the use of Frequency Shift Keying: one or other of two closely-spaced radio frequencies is transmitted, one to indicate a mark and the other a space. In essence this is a form of frequency modulation.

Either amplitude or frequency modulation can and still is used for music and speech in analogue form. FM requires a greater bandwidth, and as a result is used in the higher broadcast bands.

A third form of modulation has come into use for both analogue and digital signal transmission – phase modulation. With an analogue signal, the phase of the carrier varies in sympathy with the modulating signal, the reference point being the unmodulated carrier phase. It is often necessary to incorporate a reference oscillator in the receiver to obtain accurate demodulation. Synchronous demodulation (as in a PAL decoder) or the phase-locked loop principle can be used.

Quadrature Phase Shift Keying (QPSK)

Nicam sound, which is digital, uses a variant of simple phase modulation called QPSK – Quadrature Phase Shift Keying. Two carriers at the same frequency but with a 90° phase difference between them are used. The carriers are referred to as I and Q (In-phase and Quadrature). By shifting one or both carriers by 180°, you get four different phasors as shown in Fig. 1. These can be used to denote the four possible states (00, 01, 10, 11) of a two-bit binary code. Each state is referred to as a 'symbol'.

The three most common methods of digital TV signal delivery, terrestrial off-air, satellite and cable, will all use MPEG-2 compression in the UK. The chief differences between them will be in the modulation method employed. This is chosen to match the characteristics of the transmission medium.

Satellite Digital TV

Satellite digital TV is to use QPSK. The arrangement shown in Fig. 1 is the basis of what is called a "phase constellation map", in which phasor end points rather than the actual phasors are shown – see Fig. 2. Satellite transmission involves the use of low transmitter powers and high-gain aerial systems at the transmitting and receiving end to provide noise-free gain. The noise floor with a satellite transmission is not very low however, which is why QPSK was chosen. With a digital transmission noise tends to move, confusing the phase constellation points. With only four phasors, there is plenty of room to move before the decoding system fails to recognise what is being transmitted.

With QPSK the I and Q carriers are always at 90° with respect to each other and their amplitude is constant. This makes it fairly easy for the demodulator to recover the original modulation, particularly in the presence of noise.

Because there is no phase reference built into the receiver, it might seem to be necessary to transmit a reference to enable the I and Q carriers to be identified. Each phase change (symbol) takes a certain time to transmit. A form of QPSK in which successive phase changes are made in relation to that of the previous symbol can be used. This system, known as 'differential coding', removes the need to transmit a reference.

The transponders used for satellite transmissions are

also able to handle analogue signals sent using FM. Thus the on-board transmitters are essentially non-linear. The transmission path is noisy but is not subject to reflections (multi-path reception) and is largely free from interference. This makes QPSK the ideal choice. Down here on Earth however the situation is different.

Cable TV – 64-QAM

It is worth considering briefly the requirements with cable TV. Traditionally CATV networks have used coaxial cable for local distribution with high-quality optical-fibre transmission for the trunk networks. The weakest link in the chain determines the overall performance of the system, and the modulation method chosen for cable has to be suited to this.

Noise is not a serious problem with a modern cable network. Low-noise amplifiers are readily available and operate linearly when within their recommended ratings. The cables pass amongst buildings of all sorts and conditions however, picking up electrical interference. This is at a low level, and need not seriously impair the service. Narrow-band amplifiers are used in places to provide automatic level control of individual channels. Because of the traffic density with a modern CATV system, the channel limits are maintained closely, both in level and bandwidth.

The digital modulation system that has been chosen for cable TV is known as 64-QAM. Quadrature Amplitude Modulation (QAM) is a variant of QPSK: it employs both amplitude and phase modulation of I and Q carriers, giving in all a total of 64 combinations of phase and amplitude. These combinations are referred to as 'symbols'. The I and Q carriers retain their quadrature relationship, but there are more phase states than the simple 180° changes with QPSK.

Fig. 3 shows the phase/amplitude constellation for 64-QAM. The provision of more points in the constellation means that more data can be packed into a symbol period. But because the points in the constellation are closer together, the tolerance of 64-QAM to a noisy environment is much less than that of simple QPSK. This is not a serious consideration for cable TV. Reflections caused by impedance mismatches within the system are a problem however, and to compensate for this and for interference heavy (and expensive) coding of the signal is used. It provides comprehensive error correction.

For digital cable TV a single carrier is used for 64-QAM.

Terrestrial Digital TV – COFDM

64-QAM also forms the basis of digital terrestrial off-air TV transmissions. But the environment is much less benign than with cable. Terrestrial reception is subject to flat fading, frequency-selective fading, reflections and interference of various kinds. Frequency-selective fading is often caused by multipath effects. If the main and the reflected signals have a phase difference of 180° they will tend to cancel out.

All these problems affect an analogue signal transmission and cause some degradation of the picture and sound quality, but the nature of the analogue system is such that a picture of some sort can be obtained. Careful aerial alignment can be used to minimise the effects. With digital transmissions data loss is a more serious problem.

Although 64-QAM is the basis of terrestrial digital TV, it is not – as with cable TV – used with a single carrier. Instead, a modulation system called Coded Orthogonal Frequency Division Multiplexing

Fig. 1 (left): The QPSK modulation technique. Two carriers at the same frequency but with a 90° phase difference between them can each be shifted through 180°, giving four possible phasors each able to convey a two-digit combination (known as a symbol). Fig. 2 (centre): This way of depicting the conditions shown in Fig. 1 is called a constellation map. Fig. 3 (right): Constellation map for 64-QAM, which has 64 possible phase/amplitude states.

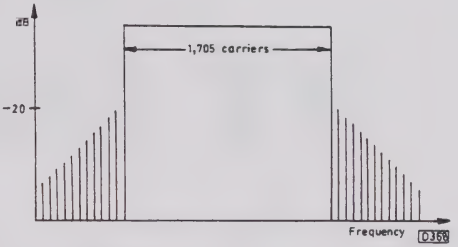


Fig. 4 (left): Spectrum of the 2K COFDM signal to be used for terrestrial off-air digital TV transmissions in the UK.

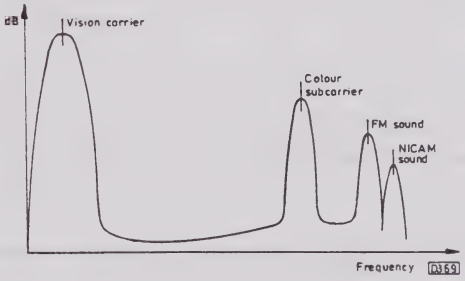


Fig. 5: For comparison, the RF energy distribution in an analogue TV channel.

(COFDM) is used. The frequency division multiplex implies a multi-carrier system; orthogonal means at right angles, so the carriers are in quadrature; coded means that some frequency interleaving and other error avoidance measures are employed to ensure a rugged transmission.

In the UK, the modulation will be split amongst 1,705 carriers. This is referred to as the 2K option: continental European broadcasters may adopt the 8K option, which uses 6,817 carriers. With the 2K option each carrier has to transport about two-thousandth the symbol rate with 64-QAM. The coding interleaves the data in time and frequency to provide enhanced error correction possibilities.

Fig. 4 shows the spectrum with 2K COFDM. The arrangement enables the 8MHz channel bandwidth to be fully used – contrast this with the analogue channel signal spectrum shown in Fig. 5. You can see that the system makes more efficient use of spectrum space.

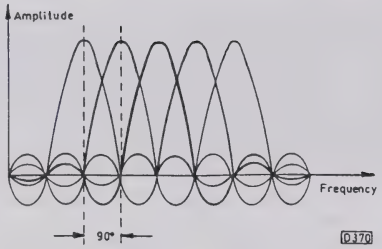


Fig. 6: Carriers with orthogonal frequency spacing – the carriers are 90° apart and don't interfere with each other.

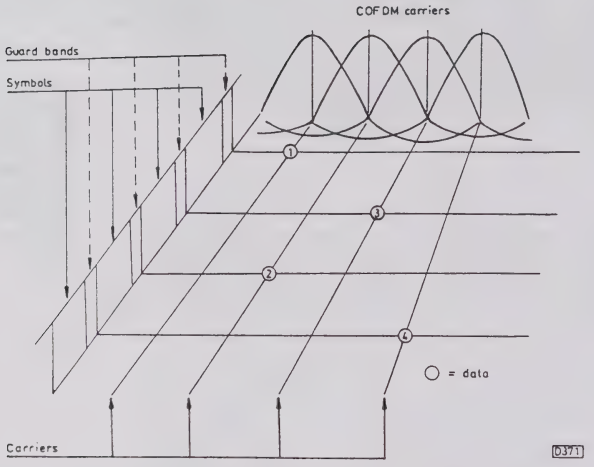


Fig. 7: Three-dimensional representation of a COFDM signal. 1-4 interleaved data.

Because of their orthogonal frequency spacing, the COFDM carriers do not interfere with each other – see Fig. 6.

Since each carrier's data rate is low, the symbol rate per carrier is much longer than with QPSK and QAM. This provides tolerance to multi-path effects. To enhance this tolerance, a guard band is added to each symbol period to lengthen it. Echoes that occur within the symbol period cause a flat signal fade. Those that occur outside it, in the guard interval, produce the effect of a phase sum and difference: the result is frequency-selective fading. The guard interval also prevents inter-symbol interference, which could present two symbols to the demodulator simultaneously – one of which would be the correct one!

Fig. 7 shows a three-dimensional representation of a COFDM signal, in time, frequency and amplitude. It also shows the interleaved data. In the event of a strong frequency-selective fade some carriers will be boosted while others are attenuated. An efficient coding system is used to identify and retrieve data lost as a result of such conditions. The coding cross-references data bits, enabling bits mutilated by fading or interference to be recovered. It is a very intricate process that's called convolutional coding – an apt description! In fact it actually makes use of echoes to improve the signal-to-noise ratio of the received signal.

Advantages of COFDM

Because of its coding and the guard interval which is added to each symbol, COFDM is very tolerant of multi-path reception. This would make it possible to use a single-frequency network (SFN) for a national broadcast service. With the same channel in use by all the transmitters that broadcast the same service, signals from distant transmitters would appear as long-delay echoes. The actual minimum separation between transmitters would be somewhere in the region of 45 miles. Because there is not a free frequency for the purpose, it is not an option in the UK at present.

The power-filled COFDM spectrum enables much lower transmitter ERPs to be used. Typically, a 5kW station in south London could cover the area from Basildon to Bracknell and Hitchin to Reigate. Much of the reception in this area would be possible using a simple set-top Yagi aerial.

Any fill-in stations required with an SFN system would again use the same frequency, making life simpler for the aerial industry and for installers. Thus the change to digital transmission could make life easier for everybody.

Analogue and digital services will have to coexist for a number of years however. It could be that the analogue services will close down as the transmitters show signs of becoming unserviceable: by that time the majority of viewers could be expected to have obtained digital receivers.

Obtaining Signals

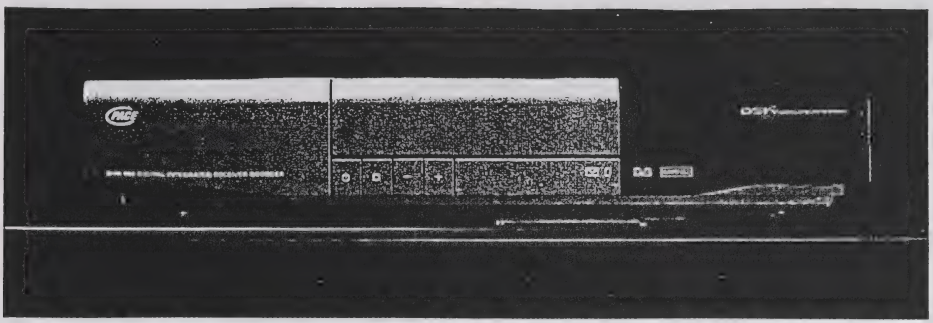
Signal seeking and aerial alignment will call for techniques different from those used for analogue transmissions. If you recall the early days of satellite TV, colour or even VHF radio, you will appreciate that we will have to go through the same learning process with digital TV.

Some digital satellite receivers have a menu page that shows a signal-strength bar graph. This assists with dish alignment, and enables the viewer to judge whether the signal has deteriorated since the dish was installed. The system works by reading the Bit Error Rate (BER), which is checked in the receiver by the error-correction circuitry. The higher the BER, the shorter the bar-graph column.

Ideally a spectrum analyser should be used for dish or terrestrial aerial alignment, as it enables optimum signal-to-noise ratios to be determined visually and accurately. To rely on the BER for aerial alignment will not always result in the best reception conditions. COFDM is capable of producing excellent pictures using a set-top aerial, but there will still be black spots – as there are with analogue services. Despite this, the digital network should provide excellent coverage throughout the country.

Summary

The coming of digital TV will change things for ever. For the viewer it will mean vastly improved facilities, with an electronic programme guide and superior quality pictures. For the service engineer it will mean a change of thinking because of the computer-like processing of the image and sound. Things will never be the same – they could even be better!



Introduction to Digital TV

What will you be looking for when faulty digital TV receivers start to appear on the bench? It's early days so far, but J. LeJeune is able to provide some preliminary guidance

In the absence of any UK digital satellite receiver models – in fact the receiver specification has only recently been confirmed – this article is simply an introduction to the black art of servicing Pace digital satellite receivers. The receivers seen so far have a family likeness: they look like the familiar analogue Models PRD900 and MSS200. But once the covers have been removed the inquisitive engineer is in for a shock – even with the mains supply disconnected!

The Pace PCB

The printed circuit board looks substantial. This is not surprising, as it consists of four layers of copper print on fibreglass substrates. The top layer carries mainly surface-mounted ICs. The second layer provides screening, to prevent crosstalk between the top layer and those beneath it. The third layer provides interconnections. The bottom, or underside, layer carries more surface-mounted discrete components, with connections to wire-ended, top-mounted components such as electrolytic capacitors and power semiconductore devices.

In terms of worry factor, the only layers that are likely to provide grounds for suicide are the buried ones. And as one of these is simply a screening plate, the one area that could cause the heart to beat a little faster is likely to be the third, interconnection layer. By now you will have realised that it can be investigated with the aid of a continuity tester. But don't use an old-fashioned buzzer: the back-EMF generated can cause a lot of damage to the 3·3V logic chips.

I have already seen some Dutch receivers with interconnection-layer faults. Problems of this sort are rectified simply by adding a jumper wire to make the required connection. Interconnection-layer failures are most likely to be caused by contamination during board manufacture: small quantities of the etchant used can be trapped when the four individual boards are fused together. In service, the board heats up. This activates the etchant, which eats its way through the copper track.

The Power Supply

The Pace digital satellite receiver uses a chopper power supply based on the now familiar TOP202 device. The circuit seems to be quite reliable, though the reservoir capacitor for the mains rectifier seems to have caused a few problems.

As power supplies are, for obvious reasons, less reliable than the rest of a piece of equipment, my guess is that most of the receivers that will eventually come into the workshop will have simple power supply failures rather than logic or other faults.

Servicing Requirements

To deal with anything other than DC faults your test equipment armoury will need to have suitable weapons, specifically a 60MHz oscilloscope, a frequency counter and a good digital multimeter. Without these items, and good eyesight, faults in the processing sections of the receiver are going to create problems.

There's a likelihood that a PC test program will be made available. It will interrogate the receiver via an RS232 port – this is a standard interface between a PC and a peripheral device, with a 25-pin D-type connector – and then provide an indication as to where the cause of the fault lies. Such a system would be invaluable for speeding up fault diagnosis.

UK receivers are likely to incorporate a fast modem as part of the specification, to provide interactive use.

Some means of testing this will also be necessary.

One very important clock signal is the 27MHz one (see Fig. 2), which is linked to the transport stream demultiplexer and is synchronised by data in the transmission. High accuracy is a basic requirement here. Even a small inaccuracy will result in loss of the picture and sound.

Repair

Once the faulty component has been located, repair has to be undertaken. The devices used in the DVR500 and DVR501 models supplied to the Netherlands are mostly of the surface-mounted type. Thus those who have serviced camcorders and subminiature audio equipment will have a head start when it comes to digital receiver repair.

Those who are new to surface-mounted devices are in for some surprises – mainly in terms of the cost of the desoldering/resoldering equipment required. Basic tools should include a strong magnifying glass, tweezers, a good bench light, a hot-air soldering tool with suitable nozzles to cater for the ICs used in the recievers being serviced, and a fine low-wattage soldering iron. You will need antistatic bench mats – and a steady hand.

If you are to carry out servicing on any scale, a proprietary surface-mounted component soldering/desoldering station is an almost essential investment. Some stainless steel probes that can be modified to produce a variety of hooks and spikes are worthwhile. For the sake of your eyes, don't attempt to service digital equipment in a broom cupboard lit by a fly-blown 40W bulb. Good lighting is a primary necessity. A thorough visual inspection can sometimes save an hour's probing with test equipment.

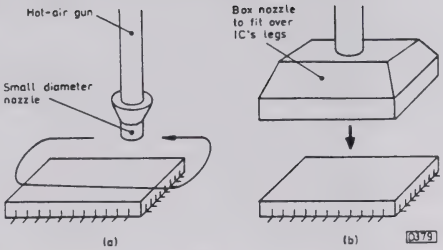


Fig. 1: Desoldering surface-mounted i Start, as shown a (a), by using a small-diameter ho air gun nozzle an a circular motion t warm the chip. Then, (b), fit a rec angular nozzle to direct heat to the IC's legs. Hold the nozzle about 2mm above the device.

IC Replacement

Once you have located the faulty component, and you are absolutely certain that it is the IC with over 100 legs, begin by warming it with a small hot-air soldering tool. Use a circular motion to heat its body – see Fig. 1. Then fit a rectangular nozzle to the hot-air tool to direct the heat to the IC's legs. Hold the nozzle about 2mm above the legs: the solder will soon melt. When bright beads appear between the IC's legs, use the tweezers to grab one corner and lift the device off the board. It all sounds quite easy, and is after some practice.

Remove the excess solder and burnt flux from the vacant copper pads. Solderwick and the hot-air tool will soon complete the first part of this operation, then use a solvent to remove the burnt flux and leave the contact area clean, ready for the replacement chip.

Check the replacement chip for possibly misaligned legs, and if necessary straighten out any irregularities

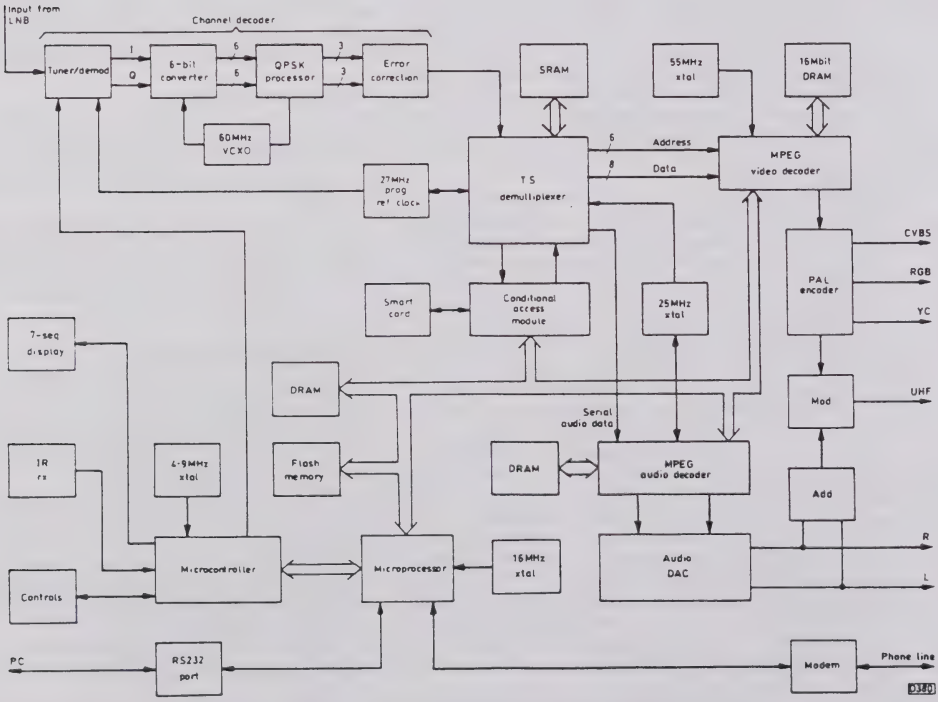
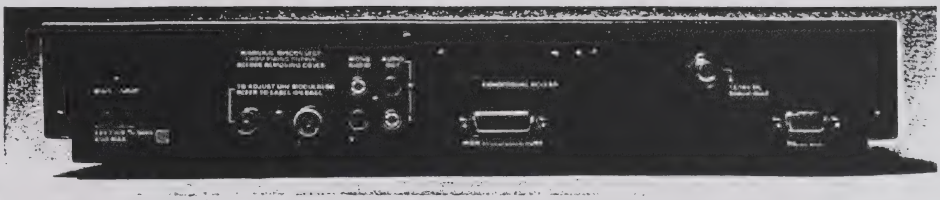


Fig. 2: Simplified block diagram of a typical digital satellite TV receiver.



Rear view of the Pace DVR500 digital satellite receiver.

before you solder the device to the PCB. Check also that the legs are tarnish free and bright looking. Prepare the PCB's solder pads by painting a thin strip of solder paste along them, on all four sides where the IC is to be mounted. Note that solder paste does not have an indefinite shelf life – keeping it stored in a refrigerator at between 3-8°C will help to prolong its life. Soldering the IC to the PCB should be a one-step operation, so make sure that the solder paste is OK by testing it on a scrap board.

Place the IC on the solder pads accurately, and make sure that it doesn't move. A level surface is best, but this is not mandatory. Fit a small nozzle to the hot-air tool and begin to circulate the hot-air stream steadily over the IC's legs at a height of about 5-6mm (a quarter of an inch). Lower the height of the nozzle gradually. Take care not to dwell on one spot for more than a couple of seconds, as this would burn the PCB material and cause electrical leakage. Do not go nearer to the IC's legs than 2-3mm.

At some point the solder paste will melt, forming bright solder around the IC's legs. Remove the heat at this stage. Allow the work to cool naturally: this will avoid heat-stress trouble, dry-joints and IC damage. Once the repair has cooled, check it for solder bridges. These can be removed by careful use of a fine-tipped soldering iron or reapplication of the hot-air gun and the use of solderwick.

Go carefully at all times, and remember that the age-old golden rule of good soldering is absolute cleanliness.

Clues

The following general outline is based on the block diagram shown in Fig. 2. The signal from the LNB, with QPSK modulation, enters the receiver at a satellite (first) intermediate frequency. Within the receiver, the tuner first converts the selected signal to a second IF of 480MHz, which is synchronously demodulated to provide separated I (in-phase) and Q (quadrature-phase) outputs. These are passed to a converter chip which produces outputs in 6-bit digital form. It operates at a sampling rate of some 60MHz, under the control of a crystal oscillator which is voltage-controlled by an output from the following QPSK processing section. This delivers 3-bit data to the forward error correction block. Some quite elaborate data processing is carried out here. The output consists of the MPEG-2 data packets we mentioned in previous instalments.

Three chips carry out most of this processing in the Pace receivers, in what is referred to as the channel decoder. The form of this decoder will vary with the transmission medium – satellite, cable or terrestrial off-air. The end result however will always be an MPEG-2 data stream.

In the event of a no-signal fault, indicated in these Pace receivers by flashing of the two bottom segments of the front panel display and the on-screen message "searching for default frequency", check the Manual Tuning Data menusbefore delving into the electronics. The data should be set to correspond with the service you want to receive, i.e.:

LNB: Local oscillator frequency; polarisation; LNB power on.

Tuner: Tuner frequency; symbol rate; FEC (forward error correction) size.

These parameters must be set correctly for the receiver to lock to the incoming signal. If the parameters cannot be set, use a scope to check for activity on the bus lines from the microcontroller chip to the channel decoder chips when the remote-control handset is being operated. Also check that the remote-control receiver is OK.

To be more specific than this is impossible at present, because the only receivers seen in the UK have been brought in by Dutch or Belgian viewers for temporary use here. UK models promise to be different. But successful operation depends on good communication between the chips used in the channel decoder. A 60MHz scope can be used to check the clock and data signals.

The MPEG-2 data that emerges from the forward error correction chip in the channel decoder in the Pace Models DGT400, DVR500 and DVR501 is fed to a very large chip called the transport stream demultiplexer. This 160-pin monster has a useful pin which indicates whether the incoming data is good enough to process or is still so full of errors that it cannot be deciphered: pin 11 goes low when the FEC chip has been unable to correct the errors. Pin 14 is also very useful for diagnosing where the cause of problems lies. It goes high when the demultiplexer chip cannot synchronise with the incoming MPEG data, indicating that this is corrupt. The chip is clocked at 25MHz (pin 58) by a crystal oscillator which is also connected to the MPEG-2 audio decoder chip.

The demultiplexed signals are then checked to determine whether they need to be sent to the conditional access module. When a clear (unscrambled) signal is present the receivers will work without the CA module being plugged in. With a scrambled signal and no CA module, you will get a message telling you to insert it. You also need a viewing card, which fits in a slot in the receiver's front panel, behind a door.

Fault finding in the MPEG decoder section of the receiver is largely a matter of checking that data and clock signals are present. Good video with poor or no audio indicates that the demultiplexer is OK and that the problem is within the audio sections. But remember that the 25MHz clock for the demultiplexer chip is controlled by the MPEG audio processor chip. If the latter fails there will thus be no activity – no sound and no picture.

As usual, checks for activity on the interrupt request (IRQ) and data strobe (DSTRB) lines can be helpful in establishing where the cause of a fault lies.

Start-up

At power up the 68306 microprocessor chip used in

these Pace sets runs the software contained in the flash memory. Assuming that all is OK and that no corrupt data is present, it instructs the NEC microcontroller chip to operate the front-panel display. Faults such as dry-joints around the flash memory or corrupted data within it, or dry-joints around the microprocessor chip, are likely to result in the receiver being stuck in the standby mode. The power supply will be operational – so beware of the nasty high voltages that will be present here.

In these receivers, as in their analogue counterparts, standby is a matter of switching off the modulator and muting the vision and sound at the rear sockets. The power supply itself is a sort of combination of the MSS100 series chopper circuit with the sensing circuit used in the MSS1000 to provide feedback for regulation.

Processing Power

Digital technology takes radio and television broadcasting into the computer age. The processing power within a digital satellite TV receiver is equivalent to that in many a desk-top computer, fast processing being a primary requirement.

Exactly which processing blocks will be contained in which chips will depend on developments in IC technology. With later developments of the original Model DVR500, like the Pace DSR200 free-to-air receiver, the audio and video MPEG processors are integrated and there is no external 55MHz clock. It appears that the 25MHz audio clock is used, possibly doubled to 50MHz within the processor.

The introduction of a Pace tuner for the company's digital models extended the frequency range – there was a problem in that the original Philips tuners covered only 950-2,050MHz. Tuner failures were common with early receivers, but later ones with second-generation Philips tuners or the Pace tuner seem to behave better in this respect.

Teething troubles are to be expected with early production receivers, and the delay in the start of digital broadcasting in the UK may be all to the good – though you could argue that early troubles provide experience for service engineers.

In Conclusion

Training in digital broadcasting techniques, particularly in receiver servicing, is likely to be a hot topic in the coming months. With some notable exceptions, the training provided by technical colleges has rapidly diminished over the last few years. Training provided receiver manufacturers such as Pace has been available to the trade, and more is expected as the actual launch of services gets nearer.

The arrival of digital broadcasting represents an opportunity for engineers to promote their services. Many less capable engineers will probably opt out, and there will be a great deal of ignorance and confusion amongst viewers and the public in general when the transmissions start. Answering their questions, giving them reassurance and repairing their quipment when faults arise will provide your business with a much-needed boost.

WHAT ARE THE OPPORTUNITIES HERE?

The world of "digispeak" is upon us. We can ignore the rapid changes which seems like a formula for early retirement, or attempt to deal with the mysterious new language and its applications. Just how encompassing is the digital evolution?

It is no evolution, rather digital is a revolution. Until now, digital encoding has been expensive which has limited the creation of digital programme channels to major programmers with the resources to invest in digital. That interim start-up era will rapidly close during the remaining months of the 20th century. Here is why.

1) MPEG-4 is upon us. No, this does not replace MPEG-2 - rather MPEG-4 is the primary digital format to support smart phones, PCs and wireless technologies. With MPEG-4, any telephone, any PC, can become a point of origination for digitised data including live, real time video. The first MPEG-4 chips from Toshiba are being released to equipment designers; picture this - 3 million transistors on one 9mm square chip! Under US$100 initially, much cheaper shortly.

2) New generation MPEG-2 chips are equally close to release. Matsushita and Toshiba are showing complete MPEG-2 encoder plus decoder functions on a single low voltage, low power consumption chip. The Matsushita chip crams 5.5 million transistors onto a single 100mm square chip (no, you won't be servicing this with your bench soldering iron!) that allows MPEG-2 encoding to be done on a parallel, multitasking approach. The DTV camera (camcorder) will create digital data flow to the recording medium (or convert analogue inputs to digital for broadcast or transmission purposes) with this single IC supported by a pair of 16 Mbyte SD-RAM chips.

3) The new approach allows complete system on a (single) chip processing of digital data in both directions (encoding, decoding) for a start up chip cost of under US$100 (and this will drop very rapidly).

What all of this means is that digitising of video (and companion audio) will shortly become less costly than analogue, with the attendant benefits of being digital at the end. The business opportunity here is to be first in your area to be totally familiar with digital processing, to have the skills and equipment to install and service digital while your competition is still trying to figure out how to spell the word. Your satellite TV work is an investment in your own future because it uniquely qualifies you to be a part of the new technology while there is still an opportunity to make money at it!

The Language of Digital TV

With TV going digital, there are many new terms and abbreviations we'll have to get used to. Mark Paul has compiled the following list as a handy reference

Digital technology will involve a new way of thinking about TV. We have already seen some use of digital techniques in the world of TV, with remote control, teletext, Nicam and, in a few chassis, signal processing, but we are now on the brink of something altogether different. There is to be a major design shift from the analogue to the digital approach, and this will require a new understanding – we are not just concerned with a bit of add-on technology.

The change has been compared with that from monochrome to colour, but is in fact more radical. It will bring with it new servicing techniques, a new set of fault conditions, new test equipment, new features, new product awareness, new customer education and a new language: Digispeak! The following is your guide to digital TV Digispeak. We'll start with abbreviations, then provide definitions for the new terms you'll be encountering.

Abbreviations

AC3 A multi-channel audio system developed by Dolby Laboratories.

ADC Analogue-to-Digital Converter. Device for converting an analogue voltage waveform into a series of digital numbers.

AF Adaption Field. A data field used for adapting the PES (see later) to data transport packet length.

ADPCM Adaptive Differential Pulse Code Modulation.

ASK Amplitude Shift Keying. A digital amplitude modulation system with two states.

AU Access Unit. MPEG coded picture, sound or data frame.

B Bidirectional. Use of preceding and succeeding MPEG frames to derive a further frame (by interpolation).

B When used to refer to an MPEG video frame, the type that is derived from I and P frames.

BAT Bouquet Association Table. A table that relates DVB-SI services.

BER Bit Error Rate. Ratio of the number of erroneous bits to the total number of bits transmitted.

BIT BInary Digit, i.e. a logic one or zero. Binary means two-state, either one or zero.

BUS A group of conductors forming a circuit or route along which data or power can be sent between several ICs, circuits or pieces of equipment.

BYTE Digital 'word' consisting of eight bits – the standard size of a binary number.

CA Conditional Access. The means of restricting access to Pay-TV programmes.

CAM Conditional Access Message. Specific messages for conditional access, i.e. ECM and EMM.

CAT Conditional Access Table. A DVB MPEG-2 transmission table that identifies conditional access packets.

CAZAC/M Constant Amplitude Zero Auto Correlation. A reference symbol for terrestrial DVB.

CCIR Comité Consultatif International de Radiodiffusion. Organisation that controls international standards, frequencyes etc. Now known at ITU-R.

CCIR-601 Recommended standard form of video signal digitalisation, with a sampling frequency of 13·5MHz and YUV signals in 4:2:2 format. Now known as ITU-R 601.

CCIR-656 Recommended way of interfacing CCIR-

601 signals. The most common arrangement is 8 bits parallel multiplexed YUV.

CCITT Comité Consultatif International de Télégraphe et du Téléphone. Now known as ITU-T.

CIF Common Intermediate Format. A compromise between the European and American SIF (see later) formats. The spatial resolution is taken from the 625-line SIF (360 x 288 pixels) and the temporal resolution from the 525-line SIF (30Hz). This compromise is the basis of video conferencing.

C/N or CNR Carrier to Noise Ratio. Received carrier power to noise power in the channel bandwidth expressed in dB.

COFDM Coded Orthogonal Frequency Division Multiplex. See OFDM. Modulation technique to be used for digital terrestrial TV transmissions.

CRC Cyclic Redundancy Check. Used to check the correctness of data.

CSA Common Scrambling Algorithm. The scrambling algorithm specified for DVB.

CVBS Composite Video Baseband Signal. This relates to analogue TV – it's the composite luminance, colour and sync PAL, NTSC or Secam signal.

DAB Digital Audio Broadcasting. The new European digital audio broadcasting standard.

DAC Digital-to-Analogue Converter. Device for converting a series of digital numbers into an analogue signal waveform.

DAVIC Digital Audio VIsual Council. The council, based in Geneva, has members from all the industries involved in the application of digital technologies to audio and video. It aims to define and specify interfaces to provide maximum interoperation between countries, applications and services.

DBS Direct Broadcasting by Satellite, i.e. from a satellite to individual dishes. The original DBS band reserved for TV broadcasting was 11·7-12·5GHz. Other sections of the Ku band have come into use for DBS, i.e. 10·95-11·7GHz and 12·5-12·75GHz.

DC Direct Current, also refers to the null-frequency coefficient in DCT (see below).

DCT Discrete Cosine Transform. JPEG/MPEG technique in which a pixel data block is converted from temporal to frequency form.

DiSEqC Digital Satellite Equipment Control. Method of modulating a 22kHz tone to provide control of LNB etc. switching.

DPCM Differential Pulse Code Modulation. Method of coding a value in terms of its difference from the previous value.

DRAM Dynamic Random Access Memory. A read/write memory whose stored data requires periodic 'refreshment'. The most common type of memory, because of its low cost.

DSM Digital Storage Medium. Term given to such mass storage devices as a hard disc, tape or CD/DVD.

DSP Digital Signal Processor. Chip used for processing digitalised analogue signals.

DTS Digital Time Stamp. Indicator of the decoding time of an MPEG access unit.

DVB Digital Video Broadcasting. In Europe there are three variants, DVB-C (cable), DVB-S (satellite) and DVB-T (terrestrial off-air).

DVB-CI Digital Video Broacasting Common Interface. Used for conditional access modules in the PCMCIA format.

DVB-SI Digital Video Broacasting System Information. A group of tables with specifications additional to MPEG-2 programme specific information (see PSI).

Eb/No Ratio between the average bit energy Eb and the noise density No. It's related to C/N.

EBU European Broadcast Union. An organisation that brings together the main European broadcasters and, amongst other things, works on new standards which then require ETSI approval.

ECM Entitlement Control Message. The first type of conditional access message with the DVB standard.

EEPROM Electrically Erasable Programmable Read-Only Memory. ROM that can be both read from and written into. It's not suitable for use as a RAM as the write process takes considerable time. Also known as an EAROM – Electrically Alterable ROM.

EIT Event Information Table. A DVB-SI table that indicates a new event.

EMM Entitlement Management Message. The second type of conditional access message with the DVB standard.

EPG Electronic Programme Guide. A graphical user interface giving easy access to DVB programmes.

EPROM Erasable Programmable Read-Only Memory. A ROM that can be programmed/reprogrammed. Erasure is by UV light, programming by a device that supplies pulses to determine the state of individual memory cells. This device is software controlled.

ES Elementary Stream. The data output from an MPEG audio or video encoder.

ETSI European Telecommunications Standards Institute. The organisation that confirms European standards in the telecommunications field. Such a standard is called an ETS.

FEC Forward Error Correction, also known as Channel Coding. This is the addition of coding to the MPEG signal to enable errors to be detected and corrected at the receiving end of the transmission path.

FFT Fast Fourier Transform. Method of processing a digital signal.

FIFO First In First Out. Refers to the flow of information into and out of a type of memory used as a buffer.

FSK Frequency Shift Keying. Modulation technique that uses a frequency shift to indicate the change of state of a digital signal from zero to one or vice versa.

GOP Group of Pictures. An MPEG video 'layer', i.e. a group of twelve MPEG video frames (pictures) starting with an I (intraframe-coded) picture.

I In-phase or Intra. The first relates to QAM (quadrature amplitude modulation), indicating the carrier on the 0° axis. The second relates to a complete MPEG frame (the first in a series of twelve) which is used on its own and then as a reference for further frames in the group.

I²C Inter Integrated Circuits. IC interconnection system via a serial bus. Originally developed by Philips.

I²S Inter Integrated Sound. System for interconnecting digital sound ICs via a serial bus, developed by Philips.

IEC International Electrotechnical Commission. International organisation for standardisation in the field of electrotechnics, electricity and electronics.

IEEE 1284 Bidirectional high-speed parallel data interface (an enhanced Centronics Interface).

IEEE 1394 High-speed (up to 400Mbits/sec) serial data interface. Is likely to become the standard for digital AV links with consumer electronic equipment.

IRD Integrated Receiver Decoder.

ISI Inter Symbol Interference. Interference between successive symbols in a digital data transmission.

ISO International Standards Organisation. The international standards organisation within UNO.

ITU International Telecommunications Union – the world regulatory organisation for telecommunications. Previously CCIR/CCITT.

JPEG Joint Photographic Experts Group. The group that set the standard for video compression with still pictures.

MP@ML Main Profile at Main Level. The main DVB standard video format.

MPEG Motion Picture Experts Group. The group that has establish video compression standards for moving pictures. There have been four standards to date. MPEG-1 is designed for CD-ROM and CD-I applications. MPEG-2, providing higher quality, is designed for broadcast and DVD use. MPEG-3 was to be used for digital HD-TV but has been abandoned – the requirement is now catered for by upper levels added to the MPEG-2 standard. MPEG-4 is still being developed and is not expected until the year 2000. It will be used for low bit rate audio/video compression (10kbits/sec-1Mbits/sec for moving pictures, 2-64kbits/sec for the associated sound).

MUSICAM Masking Universal Sub-band Integrated Coding And Multiplexing. Coding process for MPEG-1 audio, layer 2, used for DAB and DVB.

NICAM Near Instantaneous Companded Audio Multiplexing. Digital sound system used with analogue TV. Employs QPSK modulation with two carriers at 6MHz and 6·552MHz (UK standard I).

NIT Network Information Tabel. DVB-SI table included in a transmission to provide information such as channel numbers and frequencies.

OFDM Orthogonal Frequency Division Multiplex. Modulation system in which the signal modulates a large number of carriers within the channel bandwidth. The carriers are all spaced apart by 90°, i.e. they are orthogonally related. There is therefore no interference between them.

P Predictive: refers to every fourth frame in an MPEG GOP. These frames are derived from the I frames and are in turn used to derive the B frames.

PAT Programme Allocation Table. A DVB table which indicates the PID of the data packets that comprise a programme.

PCM Pulse Code Modulation. Pulse modulation to convey information.

PCMCIA Personal Computer Memory Card International Association. Since renamed **PC-CARD**. The format used for PC extension modules and proposed by DVB for detachable CA modules using the DVB-CI (common interace).

PCR Programme Clock Reference. Information sent at regular intervals with an MPEG-2 transmission to synchronise the receiver's decoder clock with the clock of the programme being received.

PES Packeted Elementary Stream. MPEG data streams (elementary streams) when arranged in packets for transmission as part of a multiplex.

PID Packet IDentifier. Number used to identify packets in a DVB transmission (MPEG-2 multiplex).

PMT Programme Map Table. A DVB table which enables all the programmes in an MPEG transmission multiplex to be identified.

PRBS Pseudo Random Binary Sequence. A signal scrambling technique.

PSI Programme Specific Information. Information, such as CAT, NIT, PAT and PMT, included in a DVB MPEG transmission to keep track of the data in the multiplex.

PTS Presentation Time Stamp. Data that marks the timing of a presentation unit.

PU Presentation Unit. A decoded MPEG audio or video frame.

Q Quadrature. The relationship between two signals/carriers with a phase difference of 90°. In relation to QAM, the carrier on the 90° axis.

QAM Quadrature Amplitude Modulation. Amplitude and phase modulation of two carriers at the same frequency but with a 90° phase difference.

QEF Quasi Error Free. A channel in which the BET is less than 10^{-10}.

QPSK Quadrature Phase Shift Keying. Modulation of one or both of two orthogonal (90° phase difference) carriers to obtain four possible signal conditions (phasors) at 45°, 135°, 225° and 315°.

RISC Reduced Instruction Set – Computer. System used to achieve more efficient use of computer ROM.

RLC Run Length Coding. Data compression system that exploits data repetition.

RSC Reed-Solomon Code. An abbreviated version of this error-correction technique is used for DVB transmission.

RS232 An asynchronous serial data interfacing standard. Data transfer is relatively slow.

RST Running Status Table. An optional DVB-SI table that provides information on the current transmission status.

SCR System Clock Reference. Sync signal sent at regular intervals with MPEG-1 compressed information to synchronise an MPEG decoder's clock with the system clock.

SDRAM Synchronous Dynamic Random Access Memory. Memory used in MPEG decoders as a high-speed RAM. The memory is 16- instead of 8-bit organised.

SRAM Static Random Access Memory. RAM that does not require data refreshment.

SDT Service Description Table. A DVB-SI table that provides information on the services in a transmission.

SIF Source Intermediate Format. The basis of MPEG-1 compresssion.

ST Stuffing Table. An optional DVB-SI table.

TDT Time and Date Table. A DVB-SI table used to updata a receiver's real-time clock.

TPS Transmission Parameter Signalling. Use of pilot carriers with DVB-T to indicate modulation and channel coding in the OFD multiplex.

VLC Variable Length Coding. Compression technique in which fewer bits are used to code frequently than less frequently occurring data patterns.

VLIW Very Long Instruction Word. A new method of microprocessor operation.

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DiSEqC Explained

K. Rutherford describes the DiSEqC satellite TV switching system, which was devised by Eutelsat to simplify LNB selection and control various other satellite reception parameters

It's time we took a look at the DiSEqC (Digital Satellite Equipment Control) system to see what it does and how it works. To appreciate why it was devised, we have to go back a little to the days when Astra, at 19·2°E, reigned alone in the European DTH satellite TV firmament. It was all very straightforward in those days. The LNB could be switched between vertical and horizontal polarisation simply by altering its supply voltage. Provide it with 13V and it would pass on the vertically-polarised signals. Raise the supply to 18V and it passed on the horizontally-polarised signals instead. Since the LNB's supply went up the coaxial downlead, a neat installation was guaranteed with no need for any extra wiring. With a fixed dish system, nothing else was required.

Enter Hot Bird

Then Eutelsat launched its Hot Bird satellites at 13°E, tempting viewers away from Astra. A motorised dish system could of course be used for reception from the two orbital positions, but this is an expensive option when signals from only two fairly-closely spaced satellites are required. So the usual approach is to install a second LNB alongside the Astra one and realign the dish for a compromise setting or use a dual-focus dish.

The extra LNB requires power and must be able to feed its signals to the receiver. Many receivers have a second LNB input, with software to perform changeover switching between the inputs. But many receivers don't have this facility. So downlead swapping was necessary, or some sort of switching box had to be introduced to carry out the change over.

Dual-band Operation

At the same time that Hot Bird came along, signals were becoming available in the DBS band (11·7-12·5GHz) – Astra initially used the FSS band only (10·95-11·7GHz). The 'universal' LNB was introduced to provide reception in both bands, which have come to be known as 'high' and 'low' for obvious reasons. The universal LNB has two local oscillators, one working at 9·75GHz and the other at 10·6GHz. Some way of switching between the two was clearly required. So a 22kHz tone was added to the LNB supply: when the tone is present, the LNB switches to 10·6GHz local oscillator operation.

No one bothered about the high band until Astra 1E (11·7-12GHz) was launched. There had been some gnashing of teeth when Astra 1D extended the spectrum below the FSS band, providing sixteen channels between 10·7-10·95GHz. Where reception of 1D was required, it was sometimes necessary to change the LNB from one with a 10GHz local oscillator to one with a 9·75GHz local oscillator, the so-called 'enhanced' LNB.

The level of the 22kHz tone for switching to high-band operation was set at 600mV peak-to-peak ±200mV. Those wishing to switch to high-band reception get their receiver to produce the tone or use an adapter to produce it. Tone inserters have to be switched manually, or some receiver modification has to be devised. More recent receivers have built-in tone generation.

This is the way it was for some three years.

Switching Summary

The arrival of the universal LNB with its tone-switched low-/high-band operation made band selection simple while retaining the voltage switching for vertically- or horizontally-polarised signals. Few viewers bother with Astra 1E, but many have taken advantage of the 22kHz tone to switch between LNBs for Astra and Hot Bird – by using one of the tone-controlled switches that have appeared on the market. In fact at present tone switching is being used more often to select LNBs than to put an LNB into its high-band mode.

The need is now arising for those who use two LNBs to be able to switch one or both of them to high-band operation – as well as being able to select horizontal or vertical polarisation. This has been brought about by the advent of digital receivers which enable unencrypted services such as CNN to be viewed. The prospect of dig-

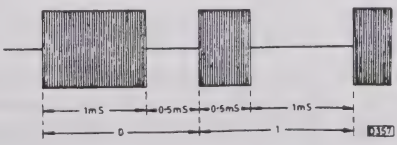

Fig. 1: DiSEqC zero and one bit codes.

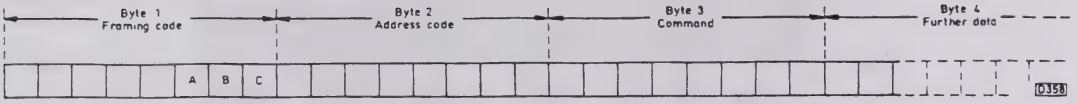

Fig. 2: The basic byte sequence for DiSEqC Version 1.0 and 2.0 commands. Byte 1 is a framing code to alert the microcontrollers in the system. Bit A is one for a command from the master device, zero for a command from a slave device. Bit B is at one if an answer is required, zero if no answer is required. Bit C is at one to indicate a repeat command because no response has been received from the slave device, at zero to indicate that the command is not a repeat one. Byte 2 is for device address. The first four bits indicate which group of devices is being addressed, the second four bits indicating the specific device – four zeros indicate a command to all devices. Byte three tells the controlled device what to do. A fourth byte can provide further command information, e.g. dish position, skew control etc.

ital broadcasts from BSkyB, Cable and Wireless etc. will increase the need for head-end switching.

To summarise, we need a way of selecting H or V polarisation, high- or low-band LNB operation and between alternative LNBs. For future-proofing, we should have some additional control functions in reserve.

DiSEqC

Eutelsat has come up with the answer, a switching system called DiSEqC. It's hardly a snappy title, but it does mean what it says – digital satellite equipment control. It has already been accepted by equipment manufacturers as a new standard. The system has been designed so that its use can be extended without making existing installations obsolete.

The trick is to modulate the 22kHz tone, enabling it to carry digital information. A whole new set of commands can thus be devised and implemented. They are fed to the LNB(s) via the existing coaxial downlead.

Bursts of 22kHz tone are used to represent either zero or one. Fig. 1 shows the zero and one bit codes.

Levels

There are three levels of DiSEqC operation. These are known as Simple DiSEqC, DiSEqC Version 1.0 and DiSEqC Version 2.0.

Simple DiSEqC is used for switching between two universal LNBs. One long burst lasting 12·5msec or a series of nine one bits tells a DiSEqC switch to select LNB A or B, i.e. one satellite or the other.

Version 1.0 uses bytes of data for control purposes. It enables up to four universal LNBs to be controlled, with information on polarisation and oscillator frequency contained in the data stream. This is a unidirectional control system.

Version 2.0 is bi-directional, with provision for return messages from the controlled devices to the control section of the receiver. This enables the receiver to check the state of the controlled item. The system can thus be used for additonal applications such as the control of a motorised dish. A single coaxial cable carries everything except the motor supply.

Fig. 2 shows the basic byte sequence used for Version 1.0 and 2.0 commands.

Receivers that implement Simple DiSEqC and Version 1.0 are already on the market, with ICs for the system in mass production. DiSEqC generators to enable older receivers to be used with the switching system are expected to become available.

Fig. 3 shows basic LNB control arrangements.

Trade Mark

Note that DiSEqC is a trade mark registered by Eutelsat. Development of the software for the control system was undertaken by Philips.

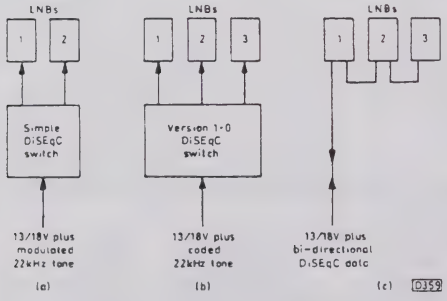

Fig. 3: Basic LNB control arrangements. (a) Simple DiSEqC with a switch to select between two LNBs. (b) A Version 1.0 switch controlling three LNBs. (c) An arrangement with three DiSEqC-compatible LNBs.

L-Band Distribution Systems

L-band distribution systems have become the next frontier for system installer/contractors. With a rapid growth in MDU (multiple-dwelling-unit) installations scheduled over the balance of 1998 and throughout the coming several years, the technology of using a single - shared - TVRO antenna system and distributing the services to multiple IRDs cable connected to the singular antenna has become very important.

This area of commercial activity began at the private home installation level (two or more IRDs), has rapidly grown to include apartment and other buildings with multiple family occupation, and will shortly explode in the Internet distribution world as IHUG and other Internet distributions shift from terrestrial to satellite distribution platforms.

Members with experience in this new area, especially in the design and implementation of coaxial cable distribution systems covering the frequency range up to 2,150 MHz, are asked to communicate with SPACE to participation an industry research programme.

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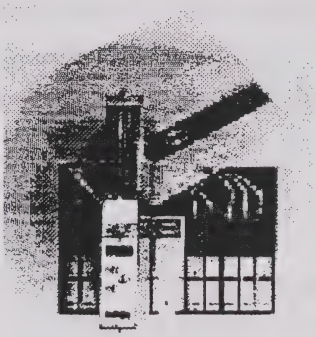

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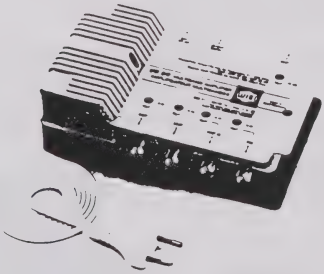

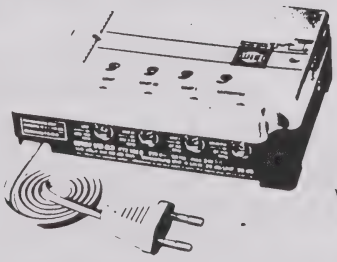

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Pacific Antennas Limited

General distributors of transmit capable and receive only satellite antennas and TVRO systems covering Australasia and the Pacific Islands

Pacific Antennas Ltd. offers equipment, advice and hands-on assistance in all satellite related ventures. We also have the following units in stock for your immediate use.

1 - only 13m Standard 'B' Vertex Antenna
1 - only 10m Scientific Atlanta Receive Only Antenna
1 - only 5m RSI transmit capable Antenna
1 - only 4.5m Scientific Atlanta Receive Only Antenna
1 - only 3.7m Com Tech Transmit Capable Antenna
1 - only 7m Telesat USA Mesh fully motorised Antenna
2 - only Sat Tel 7m Fibreglass Antennas
15 Analogue Receivers (some new, some used)
10 Various C and Ku band feedhorns
8 C-band LNBs
8 Ku-band LNBs
8 smaller dishes from 12" to 48"
6 Satfinders
1 - only PSA Spectrum Analyser
1 - only Promax Spectrum Analyser
1 (one) set of foundry patterns for 5m antenna mounts
2 functional moulds for fibreglass antennas
6 (six) 3.7m Mesh Antennas (some still as new in boxes)
1 (one) 3m Mesh Antenna (still in box)
5 - 24" Jack Screws
3 Auto Tracking Units
-AND last but hardly least, more than a decade of pioneering experience in the design, construction, installation and proofing of transmit and receive satellite antenna systems up to 13 metres in size throughout the Pacific!

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SPECIAL OFFER
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MEMBERS ONLY-

AS a FOUNDING MEMBER
Bay Satellite TV has actively backed SPACE Membership.

Until May 15th - 20% off all ADL feeds to Installer/Dealer Members!

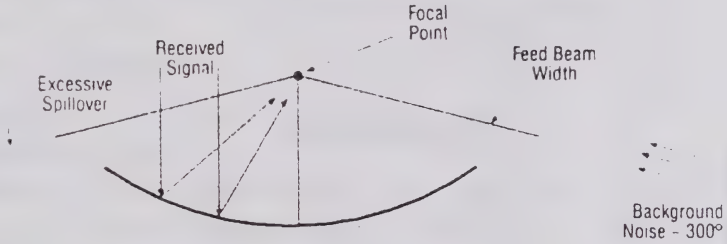
UNCLE BAYSAT ASKS ...

Are your feeds getting too much ground noise, or, too little signal?

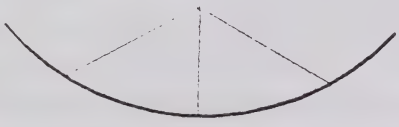
The Free-to-Air Sports Pacific Network on Intelsat 180 is a true test of whether a dish system is functioning properly or not. This right hand circular transmission requires a quality RHC feed that ignores ground noise.
Our ADL CP300 and CP400 feeds are proving themselves daily on this difficult SCPC service. Do you want Free-to-Air sports?
See us for an ADL feed for your dish system today!

NOBODY would purposefully point their satellite dishes directly into the ground expecting to receive satellite signals! YET - that is what you do if you select the wrong feed for your particular dish. No decision you make concerning packaging a DTH system is more important than the choice of the correct feed for the dish!

A FEED that OVER illuminates your dish might as well be pointing at the ground picking up terrestrial noise! Signal levels may measure good but your signals are buried in noise; not good!



OR, a feed that UNDER illuminates the dish only receives from a portion of the surface, throwing away dBs!



Don't leave dBs behind at the dish - get all of the signal your system is capable of producing!

Uncle Baysat recommends and uses for our own installations the versatile ADL range of feeds - there is ONE correct feed for every dish installation - ADL makes it and Uncle Baysat has it in stock!

AND -

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SPACE PACIFIC Digital Satellite TV Installer Certification Course

For anyone who may not currently have a solid technical background but has the desire to learn about digital TVRO technology and is ready to absorb the basics required, one step at a time and at a pace that fits their personal needs.

COURSE OUTLINE
Our graphically intensive, step by step tutorials cover:

☐ ***Satellite 101:*** *frequencies and wavelengths, satellite orbits, satellite power, "footprints" and rain attenuation.*

☐ ***Digital video compression:*** *from analogue to digital, bit rates, MPEG, DVB forward error correction, symbols, coding, bit error rate, and digital IRD threshold.*

☐ ***Feedhorns and LNBs:*** *the impact of thermal noise; LNB gain, noise temperature, stability & noise figure; feedhorn design and use, polarisation methods, hybrid feeds, and multi-feed systems.*

☐ ***Satellite TV Antennas:*** *prime focus, offset, and planar array antennas; antenna gain, G/T, side lobe performance, beamwidth, and calculating system C/N performance.*

☐ ***Satellite Receivers, IRDs and Encryption:*** *features and operational parameters of analogue versus digital IRDs plus a basic overview of encryption technologies.*

☐ ***Satellite Installations:*** *a step-by-step guide to how to install DTH TV receiving systems from locating the site & selecting the components to assembly, tracking and maintenance. Includes information on how to tune digital IRDs and troubleshoot problems with digital TV receiving systems.*

☐ ***Satellite Tools & Test Equipment:*** *how to use tools, meters and a spectrum analyser during the installation and while trouble shooting.*

☐ ***Digital DTH Platforms in the Asia/Pacific Region:*** *an overview of the digital satellite TV platforms for the Asia/Pacific region and how to receive their signals in your area.*

Graduating SPACE PACIFIC members for the Digital Satellite TV Installer Certification Program include:

- **Brendon Bell,** *Town & Country Aerial Installations*
- **Gabriel Chingue,** *Enterprise Chingue*
- **Darren Colquhoun**, *DC Electrical*
- **Bruce Gutschlag**
- **John Hoskins**, *The Antenna Man*
- **Andrew Maitland**
- **James McIntyre**, *Ruapehu Electrical Services*
- **Maurits Roos**, *Teltrac Communication*

Just a few of the many supporting comments made by SPACE PACIFIC members who have already taken and completed our courses:

- *"Simply the best investment I could have possibly made."*
- *"Far more educational materials than I ever dreamed that I would receive."*
- *"I came into the course just because I was curious. Now I definitely want to pursue satellite TV as a career choice."*

CORRESPONDENCE COURSE MATERIALS
The DIGITAL Satellite TV Installation Handbook, a one-hour *Satellite Installations* videotape, and TWO IBM computer disks containing satellite installation computer software. Also included: interaction by e-mail and regular mail with course instructor Mark Long, the final exam and the SPACE PACIFIC certificate of graduation.

NEW Register for either course before May 30, 1998 to receive a **special bonus**: a free subscription to Mark Long's *1998 Asia/Pacific* **SATELLITES ON LINE** Internet Library service.

SPACE PACIFIC *Satellite Technician Certification Course*

For those individuals who may already be technically knowledgeable but who wish to take their understanding of satellite communications technology to a higher level.

COURSE OUTLINE

The Space Segment:

☐ How communications satellites are planned, constructed, launched and operated in orbit; the transmission and reception of video, voice and data signals via satellite; the differences between geostationary, geosynchronous and inclined orbits; how to track inclined orbit satellites.

☐ The satellite electrical, communication, attitude control and antenna sub-systems; how satellite transmissions are shaped into unique coverage beams called "footprints" and how to accurately interpret the available footprint maps.

☐ The global regulatory environment, how satellites are registered, assigned to various satellite services and co-ordinated under international regulations.

☐ Satellite frequency and orbital assignments, the propagation properties of the satellite frequency bands, the impact of growing orbital congestion.

☐ Solar outages, rain fades & Faraday rotation.

The Ground Segment:

☐ Satellite controlling earth stations and broadcasting centres.

☐ TV receive-only satellite system component design and application.

☐ Satellite TV link budgets.

☐ Non-video receive-only applications, including Internet service access.

☐ DTH & SMATV installations, including downlink site surveys, installation requirements and system troubleshooting techniques.

Related Technologies:

☐ Digital video compression: terms, standards, mechanics of operation; digital problems and their solutions.

☐ Encryption system components and methods.

☐ How to use a spectrum analyser as well as other instruments and tools.

Graduating SPACE PACIFIC members for the Digital Satellite Technician Certification Programme include:

- **Tony Allen,** *AM Satellite Services*
- **Adam Bickley,** *Golden Bay Services Ltd.*
- **Pietro Casoar**, *Digitalsat Communications*
- **Richard Falkowski,** *Genesis Satellite*
- **Reiner Petrou**, *Tolec Electronics P/L*
- **Thirunesan Subramaniam,** *Measat Broadcast Network Systems*
- **Charles Wolnizer**
- *More than twenty-five additional members are currently enrolled in the two SPACE PACIFIC certification course programmes.*

TECHNICAL TRAINER (FOR BOTH COURSES) Mark Long, consultant, lecturer, author of the best-selling *World of Satellite TV* and founding publisher of the *World Satellite Almanac.*

I would like to register for the following course(s):

☐ Satellite Digital Installer Course at US$ 295.00

☐ Satellite Digital Technician Course at US$ 395.00

NEW **Special bonus** (new registrants only) until May 30, 1998. See the page opposite for details.

COURSE REGISTRATION DETAILS

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City: _____

State: _____ Country: _____

Telephone: _____

Fax number: _____

I have enclosed cheque to SPACE Pacific Ltd.

☐ In the amount of: _____

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Mail or fax form to: **SPACE PACIFIC Ltd.**,
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SPACE Member Database Survey	**INSTALLER/DEALER, RETRANSMISSION & IMPORTER/MANUFACTURER/PROGRAMMER**

The purpose of this Database survey is to allow SPACE to supply your firm's name and capabilities to satellite system network developers who are routinely contacting SPACE for qualified personnel and businesses to do C and or Ku band system installations under contract. All membership levels **except** "Individual Member" are requested to complete this survey form and return it to SPACE Pacific Ltd., PO Box 30, Mangonui, Far North, New Zealand (fax 64-9-406-0183).

NAME of your firm _____
MAILING address _____
TOWN/City _____ Region/State _____ Country_____

NAME of contact person _____
WORK telephone _____ After hours telephone _____
WORK fax _____ email _____

Experience in Installing -

C-band TVRO up to _____ metres in size
Ku-band TVRO up to _____ metres in size
MDU (multiple dwelling unit) installations using (check highest applicable)
___40-230 MHz, ___40-500 MHz, ___ 40-890 MHz, ___ 40-1450 MHz, ___ 40-2,150 MHz of up to ____ (number) outlets

Complete as applicable (yes or no) -

___ Az-El motor driven systems, ___ Polar Mount motor driven systems,
___ ortho-mode feed systems, ___ dual-band feed systems,
___ MPEG-2 or other digital TVRO systems,
___Data (such as Internet) digital receive systems,
___ Two or more dishes - same site, systems
___ Roof top, other non-ground mount antenna systems
___ Offset fed antenna systems, ___ Prime focus antenna systems

Commercial Installation Experience with - (as applicable - check off)

___ PAS-4 68.8E, ___ Ap2R 76E, ___ Th3 78.5E, ___S14 96.5E, ___As2 100.5E,
___ S21 103 E, ___ C2 113E, ___ JcSAT 3 128E, ___ Ap1A 134E, ___ Ap1 138E,
___ Me2 148E, ___ C1 150E, ___ B3 156E, ___ B1 160E, ___ Pas-2 C-band 169E,
___ Pas-2 Ku band 169E, ___ I174 174E, ___ I177 177E, ___ I180 180E

Test and Other Equipment-

___Spectrum analyser (make, model) _____
___ Other as applicable to TVRO _____

Certificates, Licenses Held -

SPACE Pacific Certification as ___ Digital Installer____ Digital Technician
Other training, licenses _____
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YES!

You may upgrade your membership status at any time.

"Individual Members" will find **REAL VALUE** in upgrading to

"Installer/Dealer!"